DOCUMENT RESUME

ED 265 013 SE 046 307

AUTHOR	Blosser, Patricia E.
TITLE	Research Related to Instructional Materials for Science. ERIC/SMEAC Science Education Digest No. 2.
INSTITUTION	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	85
CONTRACT	NIE-400-78-0004
NOTE	3p.
AVAILABLE FROM	SMEAC Information Reference Center, The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 ($1.00).
PUB TYPE	Information Analyses - ERIC Information Analysis Products (071)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Achievement; *Elementary School Science; Elementary Secondary Education; *Instructional Materials; Meta Analysis; *Science Course Improvement Projects; Science Curriculum; Science Education; Science Instruction; Science Materials; *Secondary School Science; Teaching Methods; *Textbooks
IDENTIFIERS	ERIC Digests; *Science Education Research

ABSTRACT

The first science education digest for 1985 focused on data obtained by use of meta-analysis techniques on research studies of science instruction. Instruction seldom takes place without instructional materials, so this second digest is a companion one containing a discussion of science education research on instructional materials. Data are shown which support the idea that the science curriculum improvement project materials developed after 1955 were successful in promoting student achievement in the use of science process skills, in creativity, and in higher cognitive skills at both elementary and secondary school levels. Research, however, has focused more on programs than on textbooks. Because teaching from, and with, textbooks is the dominant method of instruction in many science classes, research is needed on such areas as how students learn to use textbooks to become independent learners and how to write them to promote efficient learning. (JN)

ERIC
Clearinghouse for Science, Mathematics, and Environmental Education

1200 Chambers Road, Third Floor
Columbus, Ohio 43212
(614) 422-6717

ERIC/SMEAC Science Education Digest No. 2

1985

RESEARCH RELATED TO INSTRUCTIONAL MATERIALS FOR SCIENCE

The first science education digest for 1985 focused on data obtained by the use of meta-analysis techniques on research studies of science instruction. (ERIC users not familiar with meta-analysis may wish to refer to this digest for a brief description of the technique.) Instruction seldom takes place without instructional materials, so this second digest is a companion one containing a discussion of science education research on instructional materials.

Instructional techniques are important (see digest 1, 1985) but the use of instructional materials also influences student achievement, use of process skills, and other outcomes. Instructional materials provide the physical media through which the intents of the curriculum are experienced (Talmadge & Eash, 1979:161). A 1976 survey conducted by the National Survey and Assessment of Instructional Materials contained data indicating that more than 90 percent of the time in classrooms students are involved in learning activities with instructional materials (Tallmadge & Eash, 1979:165).

Studies of Science Curricula

A number of studies have been conducted to assess the impact of innovative science curricula. One such study was reported in Walberg's *A Meta-Analysis of Productive Factors in Science Learning Grades 6 Through 12* (1980). In a chapter entitled "Science Curriculum Effects in High School: A Quantitative Synthesis," Weinstein and others reported on the examination of 33 studies involving 19,149 junior and senior high school students in the United States, Great Britain, and Israel in order to assess the impact of innovative pre-college science curricula of the past 20 years on achievement. Weinsiein et al. confined their examination to those studies involving nationally developed innovative science programs The 33 research studies they reviewed involved 13 different curricula, 8 at the senior high school level and 5 at the junior high school level (1980:J6). The reviewers looked at (1) conceptual learning, (2) inquiry skills, (3) attitudinal development, (4) laboratory performance, (5) concrete skills (i.e., classification of properties represented by pictorial stimuli). Weinstein and his colleagues differentiated between concrete skills and inquiry skills as follows "... Unlike inquiry skills, concrete skills require only observation and classification of directly perceived objects or pictures. Inquiry skills require some form of hypothetical-deductive reasoning as in Piagetian formal operations ...." (1980:J7).

It has been suggested that outcomes of research favoring the innovative treatment are due to the use of tests biased in favor of the treatment. Weinstein et al. developed a method of analysis that would take such a possible factor into account. They reported a ratio of approximately 4:1 in favor of outcomes related to the use of innovative curricula, concluding:

> Although great national interest in science curricula by the general public and professional educators may have abated in the 1970s, the post-Sputnic (1958) curricula produced beneficial effects on science learning that extended across science subjects in secondary schools, types of students, various types of cognitive and affective outcomes, and the experimental rigor of the research. Past reviews showed the percentage of positive results; but the present analysis shows a moderate 12 point percentile advantage on all learning measures of average student performance in the innovative courses (1980:J12).

Bredderman confined his analysis to studies involving the use of one of the three major activity-based elementary school science programs: Elementary Science Study (ESS), Science—A Process Approach (SAPA), or the Science Curriculum Improvement Study (SCIS) (1983). Bredderman also used meta-analysis to compare data from 57 studies involving 13,000 students and more than 900 classrooms. He reported, "The overall effects of the activity based programs on all outcome areas combined were clearly positive, although not dramatically so" (1983:504). Thirty-two percent of the 400 comparisons favored the activity-based programs at least, the .05 level of significance. The mean effect size on all outcomes on all studies was .35, indicating about a 14 percentile improvement for the average student as a result of being in the activity-based program group (1983:504). The outcome areas Bredderman identified for his analysis included (1) science process, (2) intelligence, (3) creativity, (4) affective, (5) perception, (6) logical development, (7) language, (8) science content, and (9) mathematics. The use of activity-based programs appeared to promote student achievement in all analyzed outcome areas with the exception of logical development (1983:505).

Bredderman speculated that if activity-based programs in elementary school science were adopted across a wide variety of districts, student performance on tests of science process, creativity, and perhaps intelligence would show increases of 10-20 percentile units; reading and mathematics scores might be positively affected; and attitude toward science and science classes probably would show a small improvement. Student performance on standardized achievement tests in science content might go up slightly (1983:511). However, if the students do not continue in such activity-based programs in the higher grades, these advantages are not sustained, according to the few follow-up studies Bredderman reviewed.

Bredderman concluded:

> The accumulating evidence on the science curriculum reform efforts of the past two or three decades consistently suggests that more activity-process-based approaches to teaching science result in gains over traditional methods in a wide range of student outcomes at all grade levels (1983:513).

Bredderman's remarks are echoed by Shymansky, Kyle and Alport in an article in the *Journal of Research in Science Teaching* (1983) in which they reported on their portion of the large meta-analysis project coordinated at the University of Colorado. Shymansky and his students analyzed 105 experimental studies on more than 45,000 students, involving 27 different innovative science curricula. In their analysis Shymansky et al. grouped 18 student performance criteria into six clusters: (1) achievement-fact/recall, synthesis/analysis/evaluation, general achievement; (2) perceptions—attitude toward subject, toward science, toward teaching techniques, toward self; (3) process skills-process measures/skills/techniques, methods of science; (4) analytic skills—critical thinking, problem solving: (5) related skills—reading, mathematics, social studies, communication skills; and (6) other areas — creativity, logical thinking (Piagetian tasks), spatial relations (Piagetian tasks) (1983:389).

They reported, "... Across all new science curricula analyzed, students exposed to new science curricula performed better than students in traditional courses in general achievement, analytic skills, process skills, and related skills (reading, mathematics, social studies, and communication), as well as developing a more positive attitude toward science ..." (1983:387). The new science curricula had a positive impact on student performance for every performance criterion except student self-concept (1983:392). The reviewers speculated that the self-concept that was measured by the various investigators was a global construct rather than a subject-specific one and, if so the global self-concept probably would not change dramatically over the length of the treatment involved in the study.

Shymansky, Kyle, and Alport examined the meta-analysis data by science content area, reporting:

- for *life science*, students had more positive attitudes about science than those in the standard health and life science programs;
- for *physical science*, students performed better, except for analytic skills;
- for *general science*, students performed significantly better than those enrolled in traditional programs;
- for *earth science*, student performance on process and analytic skills was positive but gains were not as large as for biology and physics. This was the only science content area for which positive achievement results were not achieved.
- for *biology*, the mean effect sizes were consistently high Student performance in the analytic thinking area was higher than for chemistry and approached the performance level of physics.
- for *chemistry*, this content area exhibited the least impact of the new science curricula in terms of enhanced student performance;
- for *physics*, student performance was second only to biology in overall pattern of positive effect sizes. Students in new physics courses effectively gained at least one-half year of study (as compared to students in traditional courses) in terms of physics achievement and analytic thinking skills (1983:394-397).

In an article in *The American Biology Teacher* (1984), Shymansky further elaborated on the meta-analysis data related to the use of the Biological Sciences Curriculum Study (BSCS) materials. Data involving BSCS classes constituted the bulk of the codable data for biology and involved 6,035 students and five versions of BSCS materials: Yellow, Blue, Green, special materials, and advanced materials. The BSCS program was effective in enhancing student attitudes toward science, process skills, analytic skills, and achievement — in that order (1984:55). When student gender was considered, students in mixed classes responsed more favorably to BSCS biology than those in predominantly male classes, outscoring their peers in traditional courses by 30 percentile points over all performance measures (1984:56). High-IQ, high ability students showed the greatest gains in response to BSCS biology. Students from schools with over 2,000 pupils responded more favorably to BSCS biology than did those from smaller schools. BSCS programs were most effective when implemented in suburban schools, only slightly less effective in urban schools, but did not fare as well in rural areas (1984:57).

Science Textbooks

In many science classes the textbook is the primary instructional material. No meta-analysis of the use of textbooks compared to non-textbook courses were identified for this digest. However, the analysis of text materials was a major focus of a symposium held in Boulder, Colorado, in 1980, and reported in *Research in Science Education: New Questions, New Directions* (1981). (Other focus areas were investigating science understanding and investigating science classrooms.) Participants suggested that it is important to design and carry out field experiments to show connections between textbooks and schooling outcomes. This could be done via case studies.

One of the symposium participants, Deese, contended that pupils never learn how to cope with expository texts. His thesis is that textbooks are written rather than spoken. Children have mastered spoken language when they come to school. Their initial encounters are with print written in expressive language closely resembling speech. Children gradually acquire the ability to deal with narrative text of concrete description. About the time they begin reading texts containing abstractions, formal instruction in reading ceases (1981:55). According to Deese:

> Readers who are going to be the scientists, lawyers, and professional persons of all kinds in the future must learn to understand dense prose, prose in which what modifies what is hard to discover, and what needs to be inferred is not easy to determine. For someone who has not been prepared for this intellectual exercise, it is an impossible task (1981:67).

Other suggestions for needed research on instructional materials were identified by participants.

In Conclusion

Data exist to support the idea that the science curriculum improvement project materials developed after 1955 were successful in promoting student achievement in the use of science process skills, in creativity, in higher cognitive skills at both the elementary and secondary school levels. Research has been focused on programs rather than on textbooks, however. Because teaching from, and with, textbooks is the dominant method of instruction in many science classes, research is needed on how students learn to use textbooks in order to become independent learners, how teachers use textbooks, as well as on how to write textbooks in order to promote efficient learning.

REFERENCES

Bredderman, Ted. "Effects of Activity-Based Elementary Science on Student Outcomes: A Quantitative Analysis." *Review of Educational Research* 53(4): 499-518, Winter, 1983.

Robinson, James T. ed. *Research in Science Education: New Questions, New Directions*. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education, June 1981. ED 209 075

Shymansky, James. "BSCS Programs: Just How Effective Were They?" *The American Biology Teacher* 46(1):54-57, January 1984.

Shymansky, James A., Wm. C. Kyle, and Jennifer M. Alport. "The Effects of New Science Curricula on Student Performance." *Journal of Research in Science Teaching* 20(5):387-404, 1983.

Talmadge, Harriet & Maurice J. Eash. "Curriculum, Instruction, and Materials," in *Research on Teaching Concepts, Findings and Implications*, Penelope L. Peterson & Herbert J. Walberg, eds. Berkeley, CA: McCutcheon Publishing Corporation, 1979.

Walberg, H. J. et al. *A Meta-Analysis of Productive Factors in Science Learning Grades 6 Through 12*. Chicago, IL: University of Illinois at Chicago Circle, June 1980. ED 197 939

This publication was prepared with funding from the National Institute of Education, U S Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or U.S. Department of Education

Prepared by Patricia E. Blosser, Associate Director-User Services, ERIC/SMEAC